CLUSTER SPROCKETS FOR BICYCLE TRANSMISSIONS AND OTHER PRIME MOVERS

RELATED APPLICATIONS

[0001] This patent application is a continuation-in-part of Serial No. 10/414,763 filed April 16, 2003, entitled "CLUSTER SPROCKETS FOR BICYCLE TRANSMISSIONS AND OTHER PRIME MOVERS".

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a multistage sprocket assembly for a bicycle. More specifically, the present invention relates to a sprocket assembly that facilitates movement of the chain from one sprocket to an adjacent sprocket during derailing, providing smoother shifting.

Description of the Background Art

[0003] The bicycle gear-shifting mechanism is generally composed of two sprocket sets and a sprocket chain interconnecting the two sprocket sets for transferring motion from one sprocket to another. The sprocket sets are provided respectively with gears having various numbers of teeth. The gear-changing process of the bicycle is attained by an action of pulling the transmission cable so as to actuate the sprocket chain to move from one sprocket to another.

[0004] A derailleur mechanism allows a rider to selectively move the chain to a different one of the sprockets in each set of sprockets. This enables the rider to select a gear ratio that is most appropriate for the current riding conditions.

[0005] There have been many attempts to improve upon the derailing of the chain from one sprocket to an adjacent sprocket. Presently, there exists many types of transmissions that employ a sprocket assembly and a derailleur gear for selectively moving a chain from one sprocket to another adjacent sprocket so as to change the speed of the bicycle.

[0006] Basically, derailleurs function to exert a force on the chain in a location proximate to the sprocket assembly so as to force the chain into alignment with the adjacent sprocket. During derailing from one sprocket to another sprocket, the chain is forcibly urged off the teeth of the one sprocket and onto the teeth of the adjacent sprocket. Upon a full revolution, the chain is thus fully derailed from the one sprocket and is fully engaged around the adjacent sprocket, thereby completing the derailing to the adjacent sprocket.

[0007] Sprocket assemblies and derailleurs have been universally accepted throughout the bicycle industry. However, it has also been widely known that the chain may slip during derailing if the teeth of the adjacent sprocket are not fully engaged as the chain is forcibly moved off the one sprocket onto the adjacent sprocket. Slippage during shifting is highly undesirable as it causes the bicyclist to lose cadence. Moreover, chain slippage during a power stroke may cause the bicyclist to lose control of the bicycle and may even result in an accident.

[0008] A disadvantage of currently available derailleur systems is that they do not always shift smoothly under load, for example, when a rider is riding a bicycle up a hill. A

further disadvantage of some derailleur type multi-speed transmissions is that a significant amount of force is generally required to shift the chain between adjacent sprockets in one of the sets of sprockets. Therefore, if it is desired to automate the shifting function by controlling shifting with a computer-controlled actuator; for example, the actuator must be capable of supplying the necessary force. Consequently, an expensive and typically power hungry actuator is required. The result is that electronically controlled automatic derailleur type transmissions have not been widely accepted.

[0009] A major problem of the prior art is that the conventional variable speed bicycle uses the conventional sprocket of the single speed bicycle, without taking into consideration the design of the chain shifting process. In other words, when the gear changing is under way, the sprocket chain engages the other sprocket in a random manner. As a result, the chance of success of gear changing of the conventional variable speed bicycle is relatively low. In the meantime, the speed changing process is slow, while the operation feel is less smooth. In view of these drawbacks, various improvements in the sprocket structure of the variable speed bicycle have been made in recent years in the hope that the engagement of the sprocket chain and the sprocket takes place successfully with precision when the bicycle gear changing is under way.

[00010] United States Patent No. 5,192,248 entitled "Multi-stage Sprocket Assembly for Bicycle" to Nagano discloses an invention making use of the reduction in the engaging tooth height of the deformed tooth or the affixed tooth. The fixed-point gear changing is attained by means of the relay engagement

of the intermediate teeth. However, this design is costly, and the split tooth also weakens tooth strength and has negative impact on safety.

[00011] United States Patent No. 5,413,534 entitled "Chain Shift Aiding Structure for Bicycle Sprocket" to Nagano discloses a gear changing path which is provided with a support projection for bracing the waist of the sprocket chain at the time when the gear changing takes place, thereby averting the chain shifting failure which is brought about by the fall of the sprocket chain before the chain has arrived at the engaging teeth.

[00012] United States Patent No. 5,085,621 entitled "Multi-stage Sprocket assembly for Bicycle" to Nagano discloses a sprocket having the design of the slanted pocket of recess for averting the sprocket changing outer chain plate and for bracing the waist portion of the sprocket chain, so as to enhance the chance of success of gear changing.

[00013] The prior art also teaches the use of transmissions, including a "variable diameter sprocket." For example, United States Patent No. 4,634,406 entitled "Multiple Speed Transmission for Bicycles" to Hufschmid discloses a transmission, in which one of the front and rear groups of sprockets are replaced with a segmented sprocket. The segmented sprocket has a number of radially movable segments that engage the chain. By moving the segments inwardly or outwardly, the effective diameter of the segmented sprocket can be changed, thereby varying the gear ratio of the transmission.

[00014] Unfortunately, this transmission has not been commercially acceptable, because it is complicated, too heavy, inefficient, and is not well suited to automation with low powered actuators.

[00015] In addition, the prior art teaches various types of gear-tooth configurations and placements to facilitate derailing of the chain from one sprocket to an adjacent sprocket. As can be seen in such patents, tooth configuration has heretofore been optimized to allow the chain to twist axially sideways so as to more easily be derailed from one sprocket to an adjacent sprocket. The positions of the teeth on the sprockets are likewise optimized to facilitate derailing. For example, a "missing" tooth configuration has been known to facilitate derailing as the "missing" tooth space more easily allows the chain to be grasped by the tooth of an adjacent sprocket without slippage. United States Patent No. 4,348,200 entitled "Multi-speed Sprocket assembly for a Bicycle" to Terada discloses a "missing" tooth configuration wherein a reduced radius, or recess, is provided at the point of the "missing" tooth. A tooth is positioned in the reduced radius, or recess, to facilitate shifting of the gear of the chain from one sprocket to an adjacent sprocket by means of the tooth positioned in such recess.

[00016] United States Patent No. 5,192,249 entitled "Multi-step Bicycle Transmission Sprocket Assembly" to Mu discloses multi-step transmission sprocket assembly and includes a large sprocket assembly, an intermediate sprocket assembly, and a small sprocket assembly. The intermediate sprocket assembly is provided in the top surface of a predetermined tooth with a

first recess and is further provided with a chain-guiding recess located in the back side of a plurality of adjoining teeth along the reverse revolving direction of the predetermined tooth. The large sprocket assembly is provided in the top surface of a predetermined number of teeth thereof with a second recess corresponding in location to the chain-guiding recess of the intermediate sprocket assembly in the reverse revolving direction. The sprocket chain is capable of shifting from the small sprocket assembly to the intermediate sprocket assembly with speed, thanks to the first recess and the chain-guiding recess of the intermediate sprocket assembly. The second recess of the large sprocket assembly serves to avert the deflection of the sprocket chain so as to eliminate the mechanical interference of the large sprocket assembly by the sprocket chain when a transmission process is in progress.

[00017] A disadvantage presented by the MU patent is that the chain is not always engaged to the teeth, the recesses do not overlap, thus, a slip of the chain can occur.

[00018] Finally, United States Patent No. 6,293,884 entitled "Cluster Sprocket for Bicycle Transmissions and Other Prime Movers" to the present inventor, the disclosure of which is hereby incorporated by reference, discloses a multi-sprocket assembly, including a plurality of progressively-sized sprockets that are positioned adjacent to one another to define an increasing diameter sprocket assembly.

[00019] A disadvantage presented by the Chattin patent is that the cluster system does not provide a smooth derailing of the chain from one sprocket to an adjacent sprocket.

[00020] While the foregoing sprocket assemblies noted above have been recognized in the industry as providing some solutions to the problem of slippage during derailing, there is nevertheless a substantial need in the derailleur industry for cluster sprockets having configurations that optimize the derailing of the chain from one sprocket to an adjacent sprocket.

[00021] What is needed is a reasonably simple variable ratio cluster sprocket which is reasonably light in weight, yet reasonably robust, reasonably inexpensive to fabricate and readily shifted from one ratio to another.

SUMMARY OF THE INVENTION

[00022] It is an object of the present invention to provide a sprocket assembly having configurations that optimize the derailing of the chain from one sprocket to an adjacent sprocket.

[00023] It is yet another object of the present invention to facilitate the transfer of the chain from one sprocket to another quietly, safely and smoothly, so that the chain is engaged with the newly selected sprocket as rapidly as possible.

[00024] It is yet another object of the present invention to provide a sprocket assembly that is reasonably light in weight, reasonably inexpensive to fabricate, and at the same time, facilitates the derailing of a chain from one sprocket to an adjacent sprocket.

[00025] It is yet another object of the present invention to provide a sprocket assembly, including a shifting aid which facilitates shifting the chain from the larger to the smaller sprocket wheel, and when shifting from the smaller to the larger sprocket wheel under load.

[00026] It is yet another object of the present invention to provide a sprocket assembly that can be incorporated into existing bicycles without requiring substantial modifications.

[00027] The first preferred embodiment of the present invention concerns a sprocket comprising:
a perimeter,
a front face, and
a back face,
wherein gear teeth project axially from at least a first perimeter segment of said front face and wherein at least a second perimeter segment of said front face is free of gear teeth;
wherein gear teeth project axially from said back face perimeter at the at least first segment of the front face, and wherein no gear teeth project from the back face perimeter at the at least second perimeter segment of the front face.

[00028] The sprocket, according to the present invention, has a thickness equal to two times a thickness of the gear teeth. The thickness of the sprocket is between 2 to 2.5 mm.

[00029] Further, the sprocket, according to the present invention, comprises four chain-guiding recesses, equally spaced apart on the sprocket. The chain-guiding recesses are

alternatively positioned between the front face and back face of the sprocket.

[00030] The chain-guiding recesses of the front face of the sprocket are located at the second perimeter segment of the front face and wherein the chain-guiding recesses of the back face of the sprocket are located at the first perimeter segment of the front face.

[00031] The chain-guiding recess in the at least long radius of the sprocket are located in the same face of the sprocket, wherein the chain-guiding recess in the at least short radius of the sprocket are located in the same face of the sprocket.

[00032] Further, the first preferable embodiment of the present invention comprises a sprocket assembly having in combination:

at least two sprockets axially and concentrically positioned relative to one another;

said sprockets comprising a non-circular configuration having at least one long radius and at least one short radius; and

wherein the sprockets being axially aligned adjacent to one another such that said short radius of one said sprocket is axially substantially aligned with, and substantially equal in length with, said long radius of an adjacent sprocket;

wherein each sprocket comprises:

a perimeter,

a front face, and

a back face,

wherein gear teeth project axially from at least a first perimeter segment of said front face, and wherein at least a

second perimeter segment of said front face is free of gear teeth;

wherein gear teeth project axially from said back face perimeter at the at least first segment of the front face, and wherein no gear teeth project from the back face perimeter at the at least second perimeter segment of the front face.

[00033] The chain-guiding recess of adjacent sprockets overlap in order to always keep the chain engaged to the system.

[00034] The at least two sprockets are axially positioned on a wheel axis X so that the chain-guiding recess of the long radius of the sprockets is retarded 90° relative to the chain-guiding recess of the long radius of adjacent sprockets.

[00035] Further, the at least two sprockets are on a wheel axis X so that the chain-guiding recess of the back face of one sprocket is facing the chain-guiding recess of the front face of the adjacent sprocket, and the no chain-guiding recess portion of the back face is facing the non chain-guiding recess portion of the front face of the adjacent sprocket.

[00036] The second preferable embodiment of the present invention contemplates a sprocket, said sprocket comprising:

a body having a center, a perimeter, an inner side, an outer side, and a plurality of circumferentially spaced teeth extending radially and outwardly from an outer periphery of the sprocket body, wherein each tooth includes a tip and a base;

wherein the center includes at least three engaging recessions;

wherein the outer side of the body includes a recessed surface and optionally at least two raised surfaces and;

wherein each raised surface extends from the tip of each tooth to below the base of the tooth and projects from at least a first perimeter segment of said outer side and wherein at least a second perimeter segment of said outer side is free of raised surface; and

wherein the inner side of the body is free of raised surfaces.

[00037] Furthermore, the second embodiment includes a new design for a one piece spacer comprising:

a boss part;

a ring part;

wherein the ring part is placed on a circle concentric with, but larger in circumference than the boss part;

wherein the boss part includes an outer perimeter, an inner perimeter, a front face, and a back face;

wherein the inner perimeter includes engaging channels and engaging protrusions which extend in the axial direction; and

wherein the outer perimeter includes at least three projections.

[00038] Finally, the second embodiment relates to a sprocket assembly comprising the sprocket and spacer according to the second embodiment of the present invention.

[00039] One of the advantages of the new design of the sprocket and spacer according to the second embodiment of the present invention is that each sprocket independently moves

inside the assembly to meet with a chain link during the passing of a chain from one sprocket to the next sprocket.

[00040] Another advantage of the new design of the sprocket and spacer according to the second embodiment of the present invention is that because the sprocket assembly has sprockets with the tooth being displaced by less than one tooth relative to each other (even size sprocket adjacent to an odd size sprocket) it is possible to vary the relationship between the teeth of the small sprocket and the chain to engage these teeth without having to vary the phase relationship between the larger and smaller sprockets thus transferring the chain can therefore be considered as synchronous shifting.

[00041] The foregoing has outlined rather broadly the more pertinent and important features of the present invention in order that the detailed description of the invention that follows may be better understood so that the present contribution to the art can be more fully appreciated. Additional features of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[00042] For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed descriptions taken in connection with the accompanying drawings in which:

FIG. 1 shows a front view of the sprocket assembly of the invention according to the first embodiment of the present invention.

FIG. 2 is a top view of the sprocket assembly according to FIG. 1.

FIG. 3 is a side view of the sprocket assembly according to FIG.1

FIG. 4 is a front view of the sprocket according to the second embodiment of the present invention.

FIG. 5 is a front view of the spacer according to the second embodiment of the present invention.

FIG. 6 is a top view of the spacer of FIG. 5.

FIG. 7 is a perspective side view of the spacer of FIG. 5.

FIG. 8 shows a front view of the sprocket assembly of the invention according to the second embodiment of the present invention showing the spacer in a first position.

FIG. 9 is a top view of the sprocket assembly according to FIG. 8.

FIG. 10 shows a front view of the sprocket assembly of the invention according to the second embodiment of the present invention showing the spacer in a second position.

FIG. 11 is a top view of the sprocket assembly according to FIG. 10.

[00043] Similar reference characters refer to similar parts throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[00044] The present invention is based on US Application No. 010/414,763 and represents a significant advance over the technologies disclosed in U.S. Pat. No. 6,293,884, to the present inventor, the disclosure of which is incorporated in here by reference.

[00045] For the purpose of summarizing this invention, this invention comprises a multi-sprocket assembly, including a plurality of progressively-sized sprockets that are positioned adjacent to one another so as to define an increasing-diameter sprocket assembly. For use in connection with a bicycle or other prime mover, a derailleur or other mechanism is provided to forcibly derail the chain riding on one sprocket to an adjacent sprocket.

[00046] Upon derailing of the chain from the one sprocket, the chain is engaged by a tooth of an adjacent sprocket and then pulled through a rotational movement such that the chain is fully derailed from the one sprocket to an adjacent sprocket upon one complete revolution.

First Preferred Embodiment

[00047] FIGS. 1-3 show the first embodiment of the sprocket assembly **10** of the present invention. The sprocket assembly comprises a plurality of sprockets S_{1-6} that are axially positioned on a wheel axis X so as to respectively be adjacently positioned. It shall be understood that the sprocket assembly **10** of the invention may comprise a greater or lesser number of sprockets depending upon the desired transmission configuration (e.g., 18-speed or 21 -speed) for the bicycle or other prime mover in which the sprocket assembly is incorporated. Although not shown, it shall be understood that the sprocket assembly **10** of the invention may be used in conjunction with a chain and a derailleur gear (not shown), wherein the derailleur serves to derail the chain entrained around one sprocket to an adjacent sprocket of the sprocket assembly **10**. Many types of derailleurs may be employed with the sprocket assembly **10** of the invention without departing from the spirit and scope of this invention.

[00048] The present invention first contemplates the use of sprockets having non-circular configuration that includes at least one small radius and at least one long radius. There are two short radiuses forming a short diameter and two long radiuses forming a long diameter. The short and long radios are dimensioned such that a short radius of one sprocket is substantially equal in length or slightly appreciably shorter in length to a long radius of an adjacent sprocket. Further, in accordance with the principles of this invention, the individual sprockets S_{1-6} are axially aligned on the axis X of the wheel to which the sprocket assembly **10** is mounted, in a position such that the long radius of one sprocket is axially aligned or retarded relative to the short radius of an adjacent sprocket.

[00049] The sprockets, according to the invention, are axially aligned adjacent to one another such that the short radius of one sprocket is axially aligned with, and substantially equal in length with, the long radius of an adjacent sprocket. For example, in an oval configuration, the short diameter of an adjacent sprocket is axially aligned with, and substantially equal in length with, the long diameter of an adjacent sprocket.

[00050] The alignment of the short radius of one sprocket, with the long radius of an adjacent sprocket, facilitates derailing of the chain from the one sprocket to the adjacent sprocket at the point where the respective short and long radiuses are substantially aligned and substantially equal in length with each other. The derailing is accomplished by virtue of the fact that the chain need not move radially outwardly or inwardly from the sprocket on which it is engaged to an adjacent sprocket as occurs in prior art sprocket assembly wherein the sprockets are generally circular in configuration and comprise different diameters. As there is no need to move the chain radially outwardly or inwardly during derailing, the chain is allowed to be easily moved to the adjacent sprocket at the point wherein the respective long and short diameters of adjacent sprockets are substantially equal.

[00051] Figure 1 shows a sprocket assembly **10** having six sprockets, each of an eccentric oval configuration, the aforementioned relationship results in adjacent sprockets having diameters that are substantially equal in length in at least five positions. For example, as shown in FIG. 2, the short diameters S_{2s} and S_{4s} of sprockets S_2 and S_4 are substantially equal or slightly appreciably greater in length to the long

diameters S_{3L} and S_{5L} of respective adjacent sprockets, S_3 and S_5, respectively. Similarly, as shown in FIG. 3, the short diameters S_{1S}, S_{3S} and S_{5S} of sprockets S_1, S_3 and S_5 are substantially equal or slightly appreciably greater in length to the long diameters S_{2L}, S_{4L} and S_{6L} of sprockets S_2, S_4 and S_6, respectively.

[00052] The long radius of the sprockets may be retarded relative to the short radius of adjacent sprockets, preferably by about one tooth, and assures that the distance between respective disengaging and engaging teeth of the adjacent sprockets is equal to the pitch of the chain, thereby facilitating smoother chain derailing. Furthermore, it is noted that several of the teeth along the area of the adjacent equal-in-length diameters of the sprockets may be specially configured to be easily disengageble and engagable by the chain during derailing.

[00053] What differentiates the sprocket assembly, according to the first embodiment of the present invention, from the sprocket assembly of the prior art, and especially to the sprockets disclosed in United States Patent No. 6,293,884 to the same inventor, is that the sprocket of the present invention is thicker than the prior art sprocket. In order words, the sprocket has a thickness **T** equal to two times a thickness of the gear teeth.

[00054] The thickness of the gear teeth is normally between 1 to 1.35 mm, thus the thickness **T** of the sprockets of the present invention is approximately 2-2.5 mm.

[00055] The sprocket, according to the first embodiment of the present invention, comprises:

a perimeter **15**,

a front face **30**, and

a back face **40**,

wherein gear teeth **14** project axially from at least a first perimeter segment **13** of said front face **30**, and wherein at least a second perimeter segment **16** of said front face **30** is free of gear teeth;

wherein gear teeth **14** project axially from said back face perimeter at the at least second segment **16** of the front face **30**, and wherein no gear teeth project from the back face perimeter at the at least first perimeter segment **13** of the front face **30**.

[00056] Having the sprockets approximately thicker than the gear teeth allows each sprocket to include chain-guiding recesses **20** in the surface of the gear teeth **14** without affecting the engagement of the chain.

[00057] The each chain-guiding recess **20** runs from the tip **25** of each tooth **14** to the base **28** of the tooth **14**. In other words, each chain-guiding recess **20** runs through the entire depth of the tooth.

[00058] In order for the chain to engage the teeth, it is essential that the thickness of each chain-guiding recess **20** correspond to approximately the thickness of the gear teeth.

[00059] Each sprocket is designed in such a way that includes four chain-guiding recesses **20**. Each chain-guiding recess

comprises ¼ of the size of the sprocket. The chain-guiding recesses **20** are arranged on each sprocket in such a way that the chain-guiding recesses **20** are alternatively positioned in the front face **30** and back face **40** of each sprocket.

[00060] The chain-guiding recesses **20** in each one of the two long radiuses of each sprocket are located in the same face of the sprocket, while the chain-guiding recesses of the two short radiuses are located in the same face of the sprocket. In other words, if the chain-guiding recesses of the long radius are located in the front face **30** of the sprocket, the chain-guiding recesses in the short radius are located in the back face **40** of the sprocket.

[00061] The chain-guiding recesses **20** of the front face **30** of the sprocket are located at the second perimeter segment **16** of the front face **30**, and wherein the chain-guiding recesses **20** of the back face **40** of the sprocket are located at the first perimeter segment **13** of the front face **30**.

[00062] It is critical for the present invention that the chain-guiding recesses **20** of two adjacent sprockets slightly overlap in order to always keep the chain engaged to the system.

[00063] The present invention further comprises a sprocket assembly, comprising in combination:

at least two sprockets axially and concentrically positioned relative to one another;

said sprockets comprising a non-circular configuration having at least one long radius and at least one short radius; and

wherein the sprockets being axially aligned adjacent to one

another such that said short radius of one said sprocket is axially substantially aligned with, and substantially equal in length with, said long radius of an adjacent sprocket;

wherein each sprocket comprises:

a perimeter,

a front face, and

a back face,

wherein gear teeth project axially from at least a first perimeter segment of said front face and wherein at least a second perimeter segment of said front face is free of gear teeth;

wherein gear teeth project axially from said back face perimeter at the at least first segment of the front face, and wherein no gear teeth project from the back face perimeter at the at least second perimeter segment of the front face.

[00064] Further, it is essential for the sprocket assembly, according to the present invention, that the chain-guiding recesses of adjacent sprockets overlap in order to always keep the chain engaged to the system.

[00065] In the present invention, the sprockets S_{1-6} are axially positioned on a wheel axis X so that the chain-guiding recesses of the long radius of the sprockets is retarded 90° relative to the chain-guiding recess of the long radius of adjacent sprockets. Thus, the sprocket is positioned in such a way that the chain-guiding recesses of the back face of one sprocket is facing the chain-guiding recess of the front face of the adjacent sprocket, and the non chain-guiding recess portion of the back face is facing the non chain-guiding recess portion of the front face of the adjacent sprocket.

[00066] Furthermore, the first embodiment of the present invention contemplates the use of sprocket having circular shape.

Second Preferred Embodiment

[00067] FIGS. 4-11 show the second embodiment of the sprocket assembly **100** of the present invention.

[00068] What differentiates the sprocket assembly, according to the second preferable embodiment of the present invention, from the sprocket assembly of the first preferable embodiment and the prior art is the new design of the sprockets and the spacers.

Sprockets

[00069] The shapes of the sprockets, according to the second preferable embodiment of the present invention, are similar to the sprockets according to the first preferable embodiment (circular or non-circular). Furthermore, distribution of the sprockets in the sprocket assembly is similar to the first preferable embodiment.

[00070] Figure 4 shows the new design of the sprocket **110** according to the present invention. Each sprocket basically has a sprocket body **120**, a center **130**, an inner side (not shown), an outer side **135**, and a plurality of circumferentially spaced teeth **140** extending radially and outwardly from an outer periphery of the sprocket body **120**. The center **130** of each sprocket **110** is provided with at least three engaging recessions **150**. The number of engaging recessions depends on the shape of the sprocket.

[00071] The inner side of the body **120** of the sprocket **110** faces the next smaller sprocket. The outer side **135** of the body **120** of the sprocket faces the next larger sprocket.

[00072] Optionally, the outer side **135** of the body **120** of the sprocket includes two different surfaces, a raised surface **270,** and recessed surface **280**. The raised surface **270** extends from the tip **290** of each tooth **140** to just below the base **300** of the tooth **140,** so that at least some of the chain links of the shifting chain can be received.

[00073] In the non-circular shaped sprocket, there are two raised surfaces located in the high side of the sprocket. In the circular shaped sprocket, there are at least two raised surfaces distributed evenly throughout the surface.

[00074] During the transfer of the chain from sprocket to sprocket, only the raised surfaces **270** of the sprocket engage with the link plates of the chain. Thus, the chain moves from a raised surface to another raised surface. As a result, the shifting chain can approach the first sprocket more closely, so that the engagement between the chain and the sprocket becomes even smoother.

[00075] The inner side of the body **120** of the sprocket only contains one type of surface.

[00076] A difference between a number of teeth on the first sprocket and a number of teeth on the second sprocket is small, e.g., from one to three teeth. Preferably two teeth, most preferably one tooth.

[00077] If desired, the shape of tooth **140** may be shaped (e.g., by tilting in the direction of chain travel, narrowing, thinning, shortening, chamfering, etc.) to further enhance the chain shifting operation.

Spacers

[00078] The present invention further comprises a new design for a spacer which is used to separate two adjacent sprockets.

[00079] The new design of the one piece spacer **160**, according to the present invention, comprises a boss part **170** and a ring part **180**.

[00080] The ring part **180** is placed on a circle concentric with, but larger in circumference than, the boss part **170**.

[00081] The boss **170** part is of the same thickness of the thickness of the center **130** of the sprocket **110**. The boss part **170** comprises an outer perimeter **190**, an inner perimeter **200**, a front face **210** and a back face opposite to the front face (not shown). The inner perimeter **200** comprises engaging channels **230** and engaging protrusions **240** which extend in the axial direction.

[00082] The outer perimeter **190** comprises at least three projections **250**. The projections **250** are rigidly mounted on the spacer **160** and sized so as to slidably engage the recesses **150** of the center of the sprocket **110**. The number of projections **250** depends on the shape of the sprocket and the number of the recession **150** of the center of the sprocket.

[00083] When the boss part **170** of the spacer **160** enters the center of the sprocket, the projections **250** engage with the recessions **150** of the sprocket **110.** Because of size of the projections **250** is smaller than the size of the recessions **150**, the projections move freely laterally inside the recessions **150** of the sprocket **110** while maintaining a mechanical linkage thereto as shown in FIGS. 8 and 10.

[00084] The new designs of the sprocket and spacer of the second preferable embodiment of the present invention allows the sprockets to move not only with the whole assembly as a group (with the movement of the hub), but also independently from the others. This feature allows the sprocket to move laterally in both directions up and down in order to meet with the chain link during the passing of the chain from one sprocket to the next sprocket.

[00085] Furthermore, the new design of the spacer and sprocket, according to the second embodiment of the present invention, allows the use of a broader range of sprocket sizes. Sprocket sizes can be chosen such that the shift pattern is essentially sequential (i.e., utilizes the entire range of freewheel sprockets on a given sprocket assembly). Thus, no complex shift pattern is required (as with prior art systems) since the gear ratios resulting from each sprocket assembly combination decrease sequentially. E.g. 15T (odd), 14T (even), 13T (odd), 12T (even). In other words, the size adjacent sprockets are different by one tooth and not three teeth as in the prior art.

[00086] The present invention provides a sprocket assembly having two sprockets with the tooth being displaced by less than one tooth relative to each other. Thus, it is possible to vary the relationship between the teeth of the small sprocket and the chain to engage these teeth without having to vary the phase relationship between the larger and smaller sprockets. Therefore, the driving load is fully transferred to the receiving sprocket long before the chain is released from the previous sprocket. For practical purposes, this method of transferring the chain can therefore be considered as synchronous shifting.

[00087] The sprocket assembly, according to the present invention, allows the chain to shift from one sprocket to the adjacent sprocket in a smooth manner, thanks to the way the sprockets are assembled in the sprocket assembly.

[00088] It should be appreciated that the sprocket assembly, according to both embodiments of the present invention, facilitates the derailing of the chain from one sprocket to another without slippage, and is, therefore, particularly useful when incorporated into a multi-speed bicycle transmission. However, it should be understood that the sprocket assembly of the invention might be incorporated into transmissions for other machinery and prime movers without departing from the spirit and scope of this invention.

[00089] The present disclosure includes that contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that

the present disclosure of the preferred form has been made only by way of example, and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention.

[00090] Now that the invention has been described,